Chapter VI - PAVEMENT DESIGN AND EVALUATION

SECTION 601 FUNDAMENTAL CONCEPTS OF PAVEMENT DESIGN

Sec. 601.01 Pavement Design

Pavement design is the process of selecting a practical and economical combination of materials of known strength and adequate thicknesses to support the anticipated traffic under expected environmental conditions.

Pavements are layered structures of varying thicknesses and characteristics, resting on subgrade soil. They are designed for the purpose of carrying vehicular traffic.

Depending on the load distribution characteristics and flexural stiffness of the pavement layers, pavements are divided into (1) flexible and (2) rigid systems. The classical definition of pavement types is rather arbitrary, being based upon the above two general pavement characteristics. The essential difference between the two system types is the manner in which they distribute the load to the subgrade soils.

In a true flexible system, the pavement lacks the inherent structural stiffness to resist the bending action of the applied load. Therefore, it merely distributes stresses to the subgrade and relies on the shearing resistance of the soils for its performance. As a consequence, the thickness design of a flexible pavement is based upon the concept of limiting the stress applied to the subgrade so that, under the worst environmental conditions, the subgrade soils' strength is not exceeded.

Generally, a flexible pavement is composed of a series of layers of granular and/or asphalt concrete materials, resting on compacted subgrade soil. The higher strength materials for carrying the traffic loads are the base and subbase layers of the structure. The thickness of the asphaltic wearing surface may be relatively thin, such as with an asphalt surface treatment, in which case the granular materials provide the bulk of the pavement's load transfer capacity.

As a flexible pavement achieves higher stiffness, it acquires a greater ability to resist the bending action of the load and consequently approaches the limiting condition of the rigid pavement definition. In fact, an asphalt concrete pavement with high stiffness could essentially behave as a rigid slab and exhibit distress (failure) manifestations similar to those of a concrete pavement. In this case, limiting horizontal strain at the bottom of the asphalt concrete layer is considered.

In a rigid pavement system, the pavement layer(s) is composed of materials of high rigidity and high moduli of elasticity which distribute a low level of stress over a wide area of the subgrade soil. Consequently, the major factor considered in the thickness design of rigid pavements is the structural strength of the pavement layer(s); i.e. - the concrete itself. Rigid pavements are classified into jointed plain, jointed plain-doweled, jointed reinforced-doweled, continuously reinforced, and prestressed. A jointed plain concrete pavement is an unreinforced pavement structure with joints at certain designated intervals to compensate for expansion and contraction forces and thermally induced stresses. In contrast, the jointed reinforced concrete pavement is a jointed pavement which contains reinforcing steel to resist the temperature induced stresses and keep the cracks formed as a result of contraction, in a tight formation. Continuously reinforced concrete pavements, on the other hand, have been designed with sufficient reinforcement to eliminate the need for joints. Prestressed concrete pavements are concrete pavements which have been prestressed and post tensioned to develop adequate internal stresses to resist traffic loadings.

A composite pavement is defined as a pavement which is generally constructed with a rigid pavement as the lower layer and a flexible pavement surfacing or wearing course on the top. The flexible (asphalt concrete) surface is designed to provide special functions such as frictional resistance, wear resistance, better traffic delineation, thermal insulation, and protection against adverse environmental effects.

Sec. 601.02 Pavement Components

(1) A flexible pavement is usually comprised of a subbase and/or base course and a surface course(s). (2) A rigid pavement usually consists of a subbase course(s) and a hydraulic cement concrete slab. Both systems are placed over the subgrade of the roadbed. The roadbed, the lowest part of the pavements' structure, is defined as the graded portion of the highway, between the top and side slopes, prepared as the foundation for the pavement structure and shoulder. The top surface of the roadbed is called the subgrade and can be mechanically or chemically stabilized to improve its load carrying capacity. Figure 1 shows a typical cross section of rigid and flexible pavement structures and their structural design terms.

(a) Subgrade

The upper surface of the roadbed, called the subgrade, is shaped to conform to the Typical Section and supports both the pavement structure and shoulders. The subgrade is the foundation of the pavement structure, and is responsible for providing a variety of performance requirements, such as, uniform support, and resistance to both traffic forces and environmentally-induced stresses.

(b) Subbase

The next layer of higher specified quality is the subbase. It is formed by the layer or layers of selected material of specified thickness placed on the subgrade to support a base course. In the case of a rigid pavement, the subbase is directly under the concrete slab.

The use of a subbase course is probably the most economical solution in the construction of a pavement over poor quality soils, where a thicker pavement structure is required. In addition to its major function of contributing as a structural member, it has other secondary functions such as:

(1) Providing permanent uniform and stable support to the overlying pavement structure.

(2) Preventing intrusion of fine-grained soils into the base course or an open graded drainage layer.

(3) Minimizing the damaging effects of frost action in special cases where the frost penetration is excessive.

(4) Acting as a drainage layer (in some cases) by preventing the accumulation of free water within the pavement system.

(5) Preventing the pumping of fine-grained soil through joints, cracks, and discontinuities under the action of wheel loads and adverse environmental conditions.

(6) Providing a working platform for construction equipment.

(c) Base Course

The layer(s) of specified or selected material of designated thickness place on a subbase or a subgrade to support a surface course is called the base course. Its material is of higher quality than that of the subbase or subgrade courses.

The base course is an integral part of the flexible pavement system, and is primarily constructed as a structural component. Depending on the structural application and design requirements, the base course might be treated with suitable stabilizing admixtures, such as cement, asphalt cement, lime, fly ash, or chemicals, in order to obtain sufficient stability, cohesion, and strength to provide added resistance to loading, or may be untreated if less traffic resistance is required. Materials that might otherwise be unsuitable for use as an untreated base course or granular base course can often provide satisfactory performance when treated with an adequate admixture such as those cited above.

(d) Flexible Pavement Surface Course

Designed as an important member of the flexible pavement structure, the surface course is the uppermost layer(s) and not only provides resistance to the applied load, but also resists the abrasive forces of traffic and the disintegrating effects of climate, reduces the amount of water entering into the pavement, provides both skid resistance and a smooth and uniform riding surface for the traveling public.

The pavement surface must be able to provide sufficient stability to resist the effects of traffic load, maintain its durability during periods of service, resist rutting and fatigue distress, and remain impervious to the effects of water. When several layers are employed as the surface course, the layer placed immediately atop the base course is commonly referred to as an intermediate (binder) course.

(e) Rigid Pavement Slab

The uppermost layer of a rigid pavement is the concrete slab which is most commonly composed of hydraulic cement concrete. This layer requires adequate strength and durability to resist the actions of traffic; it also must be able to provide adequate bending resistance for distribution of load, and have adequate skid characteristics to resist the abrasive forces of traffic. Reinforcement, such as temperature steel, dowel bars, load transfer devices, and tie bars, are provided to resist load induced stresses as well as frictional, shrinkage, and thermally induced stresses.

(f) Open Graded Drainage Layers

An open graded drainage layer base course is the newest addition to both flexible and rigid pavement structures to provide for rapid drainage of the pavement. This layer, unstabilized or stabilized with asphalt or cement, is generally used on high traffic roads and is strongly recommended for all rigid pavements. Pavement edge drains, with outlets and endwalls, are required with all drainage layers.

A booklet "Guidelines for Providing Improved Drainage Systems for VDOT Pavement Structures" is available as a guide for design and construction of a drainage layer system.

Sec 601.03 Axle Loads

The most important factor in the structural design of highway pavements is the interaction between traffic and the pavement, specifically, the influence of vehicle type, traffic volume, and traffic-induced stresses upon the pavement. The primary factors that influence traffic-induced stresses are listed below:

(1) Axle spacing.

(2) Tire spacing (single tire vs. dual tires).

(3) Load per axle or tire.

(4) Tire pressure.

(5) Number of load repetitions

During their service lives, pavement structures are exposed to various types of vehicles, with differing load configurations and magnitudes. The two most common load configurations are defined as follows:

(a) Single Axle Load

The total load transmitted by all wheels whose centers may be included between two parallel transverse vertical planes 40 inches (1 m) apart, extending across the full width of the vehicle.

(b) Tandem Axle Load

The total load transmitted to the road by two or more consecutive axles whose centers may be included between parallel transverse vertical planes spaced more than 40inches (1 m) apart, but not more than 96 inches (2.4 m) apart, extending the full width of the vehicle.

(c) Legal Axle Load

In Virginia, the legal maxium single axle load is 20,000 pounds (90 kN) and the legal maximum tandem axle load is 34,000 pounds (151 kN). The determination of allowable axle loads is influenced by the load per inch (millimeter) width of tire, tire pressure, gross weight, and axle spacing.

Sec. 601.04 Tire Pressure

The stress applied to the pavement surface (known as contact pressure) is considered, for all practical purposes, to be equal to the tire pressure.

Sec. 601.05 Load Equivalency

The traffic equivalency factor is a numerical factor that expresses the relationship of highway damage, for a given serviceability level (the current ability of the pavement to serve high-speed, high-volume automobile and truck traffic), of a given axle load to the damage of another. This factor expresses the damaging effects of an axle load in terms of equivalent numbers of repetitions of 18,000 pound (80kN) single axle loads. The equivalent single axle loads (ESAL's) is used in the design procedure (Sec. 602.02).

An equivalent single wheel load (ESWL) is defined as the wheel load of a single tire that will cause an equal magnitude of stress, strain, deflection, or distress at a given location within a specified pavement system, compared to that caused by multiple wheel loads or loads of differing magnitude.

The performance-related or experimentally-developed ESWL relationships for both flexible and rigid pavements, based upon the test results of the Maryland Test Track, the WASHO road test and the AASHTO manifestations, are equated to load applications and load parameters. For flexible pavements, the surface deflection, stress, and serviceability index were used; whereas for rigid pavements, the corner stresses, corner deflections, edge deflections, cracking and serviceability index have been used to derive an equivalent single load.

SECTION 602 VIRGINIA'S PAVEMENT DESIGN METHODS

Sec. 602.01 General Sequence of Events

(See figure 2, flowchart) - The Residency and District Offices will identify needs for new construction/ improvements, compile priority listing, and submit data to the Transportation Board for project selection and funding.

The Location and Design Division establishes schedules and submits preliminary plans and requests for a soil survey to the District Materials Office for Secondary System projects or to the Central Office Materials Division for Primary, Urban and Interstate System projects.

The Central Office Materials Division then submits plans and the soil survey request to the appropriate District Materials Engineer's Office and requests a traffic study from the Transportation Planning Division. The results of the traffic study are then made available to the District Materials Engineer, for use in preparing the pavement design recommendations.

For Primary, Urban, and Interstate projects, the District Materials Engineer submits the completed soil survey field data, recommendations, and any additional traffic data to the Central Office Materials Division. This information includes:

(1) Traffic data - projected ESAL's (18 kip) for a 30 year design period. (From Transportation Planning Division or, if not available, from District estimations.)

(2) Existing pavement thickness and condition, including history.

(3) Pavement design recommendations.

(4) Soil types and properties, including shrinkage and consolidation.

(5) Soil treatments that are necessary.

(6) Need for geofabrics.

(7) Location of soil undercut areas.

(8) Water table levels and Underdrain locations.

(9) Location of unsuitable material above subgrade.

(10) Disposition of unsuitable material.

(11) Bedrock elevation profiles and disposition of bedrock material.

(12) Slope Design Recommendation. (also see Sec. 304.03)

(13) Life Cycle Cost analysis for Asphalt and Concrete pavement options.

Similar information is furnished directly to the Location and Design Division by the District Materials Engineer on Secondary System projects.

The soils data is reviewed by the Soils and Foundations Engineers for undercut, special treatment of soil, surcharge, slopes, etc.

For Primary, Urban, and Interstate System projects, the Central Office Materials Division's Pavement Design and Evaluation Section will review all soils data, alternative flexible and rigid pavement designs, and pavement recommendations.

Sec. 602.02 Pavement Design Methods

(a) Flexible Pavement Design

VDOT uses a modified version of the AASHTO method. It was developed by the Virginia Transportation Research Council and The Central Office Pavement Design Section using thickness equivalencies of materials, soil support values (SSV), and daily equivalent single axle loads (ESAL's - 18 kip) to design pavement systems. Primary and Interstate projects are designed using a projected traffic volume based upon a 30 year design period. Whereas, a 20 year design period is used for future traffic estimates on Secondary projects. (See Sec. 601.05)

The following manuals, which define the above noted design variables and which are commonly referred to as "the Vaswani" method after their author, Dr. N. K. Vaswani, are available through the Materials Division's Pavement Design and Evaluation Section:

1. Primary and Interstate: "Recommended Design Method for Flexible Pavements in Virginia".
2. Subdivision/Secondary Roads: "Design Guide for Subdivision and Secondary Road Pavements in Virginia".

(b) Rigid Pavement Design

VDOT uses the American Concrete Pavement Association/AASHTO design program software to design rigid pavements and verifies the structural capability using AASHTO methods (computer program DARWin. These programs are based upon traffic loadings, concrete elastic modulus, modulus of subgrade reaction (K), and working stress (f) of concrete. The following design manual for rigid pavement is available through:

"AASHTO Guide for Design of Pavement Structures", AASHTO, Washington, D.C., 1993

(c) Pavement Type Selection

For Primary, Urban and Interstate projects, both flexible and rigid pavement design alternatives are analyzed for structural adequacy and life cycle costs per 24 foot (7.2 m) lane mile (km) over a 30 year period. Other engineering factors,such as existing pavement type and successful experience with each type of pavement locally, are used in the selection of a recommended pavement type. When available, microcomputer software should be employed for pavement design, design evaluation, and life cycle costing. Appendix A shows some computer pavement alternatives analyses output using life cycle cost software.

Sec. 602.03 Final Recommendations

Final recommendation are submitted to the Chief Engineer for approval. If accepted, they are transmitted to the Location and Design Division for incorporation into final plans and submission to the Federal Highway Administration (FHWA) with the Plans, Specifications, and Estimate (PS&E) assembly. (Sent to FHWA on federal aid projects only.)

Sec. 602.04 Follow-Up and Problem Identification

The District is responsible for the collection of data concerning pavement performance, maintenance, verification of traffic data, and identification of any pavement problems.

Sec. 602.05 Computer Database

A computer data base is used to provide feedback on pavement performance in order to aid in future pavement design, maintenance and rehabilitation strategies. It may also aid in correcting locations of current pavement distress. This base is also employed as a part of VDOT's Pavement Management System.

Sec. 602.06 Future of Pavement Design in Virginia

VDOT is progressing toward the implementation of the 1993 AASHTO methods of pavement design for flexible and rigid pavements. VDOT is currently evaluating the AASHTO Guide For Design of Pavement Structures 1993 and applicable computer programs (DARWin) for its application in Virginia. The program is currently undergoing extensive modifications and verification throughout the country. Prior to implementation, relationships specific to Virginia with regard to material properties, traffic projections, and evaluation procedures will have to be established and verified.

Sec. 602.07 Metric Conversion

Conversion of pavement design computer programs to the metric system will occur in the future. VDOT expects to utilize the "AASHTO Guide for Design of Pavement Structures" or metric conversion of the "Vaswani" design method. Full conversion to the metric system will depend on the recommendations of AASHTO concerning units of data input, such as traffic loadings and falling weight deflection information. Until these recommendations are available for review by VDOT, input and output for design purposes will remain in the English system. Recommendations will be converted to the metric system for incorporation into the roadway plans. Generally, layer thickness conversions will be rounded to the nearest 5 mm based on a conversion factor of 25 mm per inch.

Appendix A contains examples of computer output for Life Cycle Cost Analysis based on the metric system.

SECTION 603 PAVEMENT TESTING AND EVALUATION

Sec. 603.01 Pavement Evaluation

Pavement evaluation is the collection and use of pavement condition data for the purpose of pavement maintenance, resurfacing, restoration, rehabilitation, and reconstruction. Typical pavement condition data should include roughness, deflection testing and analysis, skid testing, and visual rating. In addition, coring and destructive testing may be beneficial.

Sec. 603.02 Roughness

Roughness testing, using the Profilograph, will be performed on all pavements subject to VDOT's rideability specifications and/or as noted in the contract and plans. Testing will take place as soon as possible after the first day of paving operation to ensure a smooth riding surface, and will continue to be performed, as soon as practical, after all subsequent paving operations. Testing will be in accordance with the latest special provision for Section 315 and 316 and/or the latest VDOT Road and Bridge Specifications applicable to the project. In addition, a vehicular mounted ultrasonic road profiler (South Dakota type) is being used to measure roughness in IRI units (inches per mile) (millimeters per kilometer) indicating the longitudinal profile or rut depth for pavement management and possible pavement quality assurance programs in the future.

Sec. 603.03 Deflection Testing and Analysis

Deflection testing and analysis will be performed on existing pavements, by the Department, using the Falling Weight Deflectometer equipment as required, and in accordance with VTM-68. The analysis is based on a mechanistic approach and designed to provide the following:

1. Determine in place resilient moduli of pavement layers and subgrade, k-value
2. Compare strength of segments
3. Evaluate load transfer efficiency across joints in concrete pavement
4. Compute predicted structural life
5. Design thickness for rehabilitation options
6. Compute life cycle costs
7. Evaluate cost-effectiveness of design alternates
8. Determine optimum time and strategy for rehabilitation
9. Develop staging plan to meet budget
10. Develop priorities

Sec. 603.04 Skid Testing

All friction (skid) testing is performed, by the Materials Division, using a trailer type skid test unit with locked inside wheel and a bald tire. The Department has two of these units, both headquartered in Lynchburg. The present skid testing program's areas of investigation are:

(1) Potential wet accident sites

(2) Major road inventory

(3) Special requests

Bald tire testing, of statewide computer selected potential wet accident sites, is generally conducted between April and August.

The Major Road (Interstate and Primary) Inventory is conducted such that, all systems are bald tire tested at least once every four years. The data collected will be used by the Districts for pavement management and other informational purposes. Request instructions are included in Appendix B.

Special request sites are run upon request.

Corrective action is usually recommended when a site's poor accident history, geometric deficiencies, or other potential site problems occur in conjunction with reported skid number values).

Corrective work, such as overlaying, grooving, grinding, etc., is handled by the Maintenance Division, when time and funds allow.

Sec. 603.05 Visual Rating

Road sections, separated by surface type, will be visually evaluated by District personnel, under the direction of the Assistant District Engineer for Maintenance, using Distress Maintenance Rating (DMR) criteria. This will be used for pavement management and other informational and planning purposes, and can be combined with other data to assess the need for an overlay. DMR results may also be used, in conjunction with deflection test results, to determine the overlay depth required to salvage an existing pavement as part of a construction project.

Sec. 603.06 Video Inspection of Underdrains and Outlets

The inspection of underdrains and associated outlets using visual and/or video camera/recording equipment to document and verify proper installation of underdrains is to be performed as follows:

Video inspection will be conducted on all reasonably accessible outlet locations up to the mainline longitudinal connection. Additionally, sufficient length of longitudinal pipe shall be inspected to assure that both installation procedures and protection measures have resulted in a functional drainage system. Special emphasis should be given to sections that have been subjected to traffic or equipment that might have caused damage. Where deficiencies are noted, additional inspection should be conducted at the discretion of the District Materials Engineer, such as to provide reasonable assurance that all deficiencies are detected.

Inspection shall be completed under the direction of the District Materials Engineer and will typically take place prior to the placement of the final surface course. Inspection reports shall be retained as part of the project records.

The video inspection camera shall be fitted to inspect both 4 inch(100 mm) and 6 inch(150 mm) pipe. The outside diameter of the fitted camera assembly shall be the following:

Pipe Size	**Camera Assembly Diameter**
4 in.(100 mm)	2.75 $\pm$ 0.25 in (70 $\pm$ 6 mm)
6 in.(150 mm)	4.125 $\pm$ 0.375 in (105 $\pm$ 12 mm)

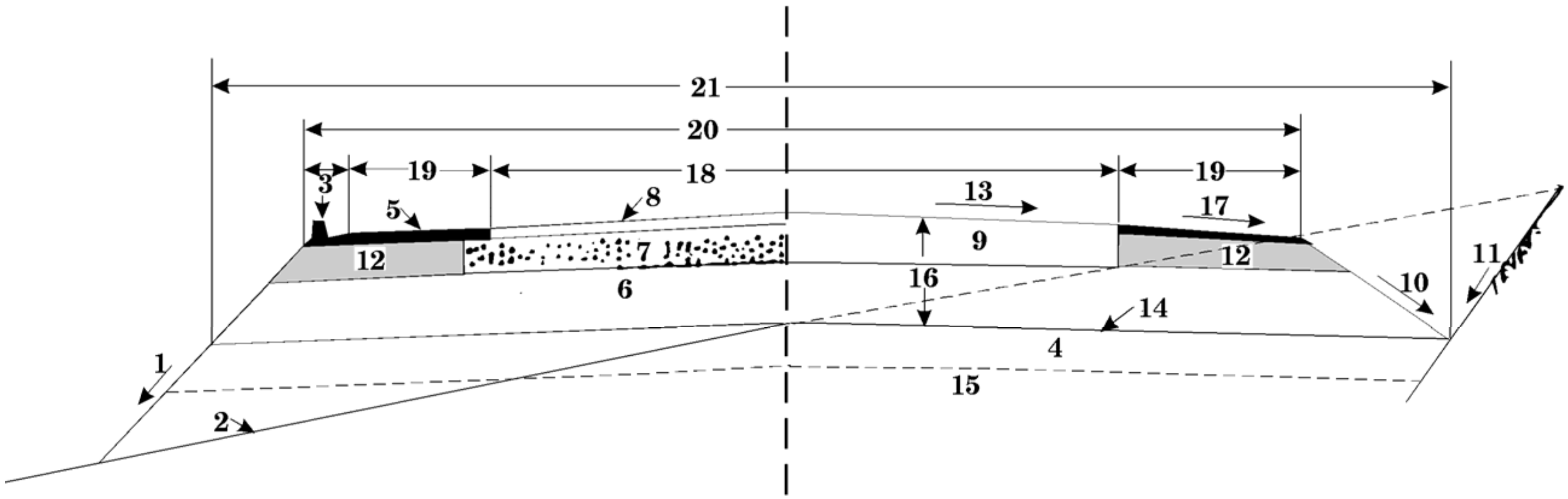
Deficiencies found during the inspection shall include but not be limited to the following:

1. Crushed or collapsed pipe that prevents passage of the camera.
2. Pipe that is partially crushed or deformed for a length 12 inches(300 mm) or greater, but allows passage of the camera.
3. Any blockages or sediment buildup caused by rodent’s nests, open connections, and cracks or splits in the pipe.
4. Sags in the longitudinal profile as evidenced by ponding of water for continuous lengths of 10 feet(3.0 m) or greater.
5. Endwalls and/or outlet pipes that are sloped with less than a uniform 2% positive slope toward the outlet.
6. Inadequate outfall of less than 6 inches(150 mm) from the pipe outlet to the bottom of the ditch.
7. Pipe that has been penetrated by guardrail posts, sign posts, delineator posts, etc.

It is suggested that video logging be used when any of these deficiencies are observed.

SECTION 604 APPENDIX

The following pages are figures, computer printouts, and non-destructive testing request instructions as referenced in the text.

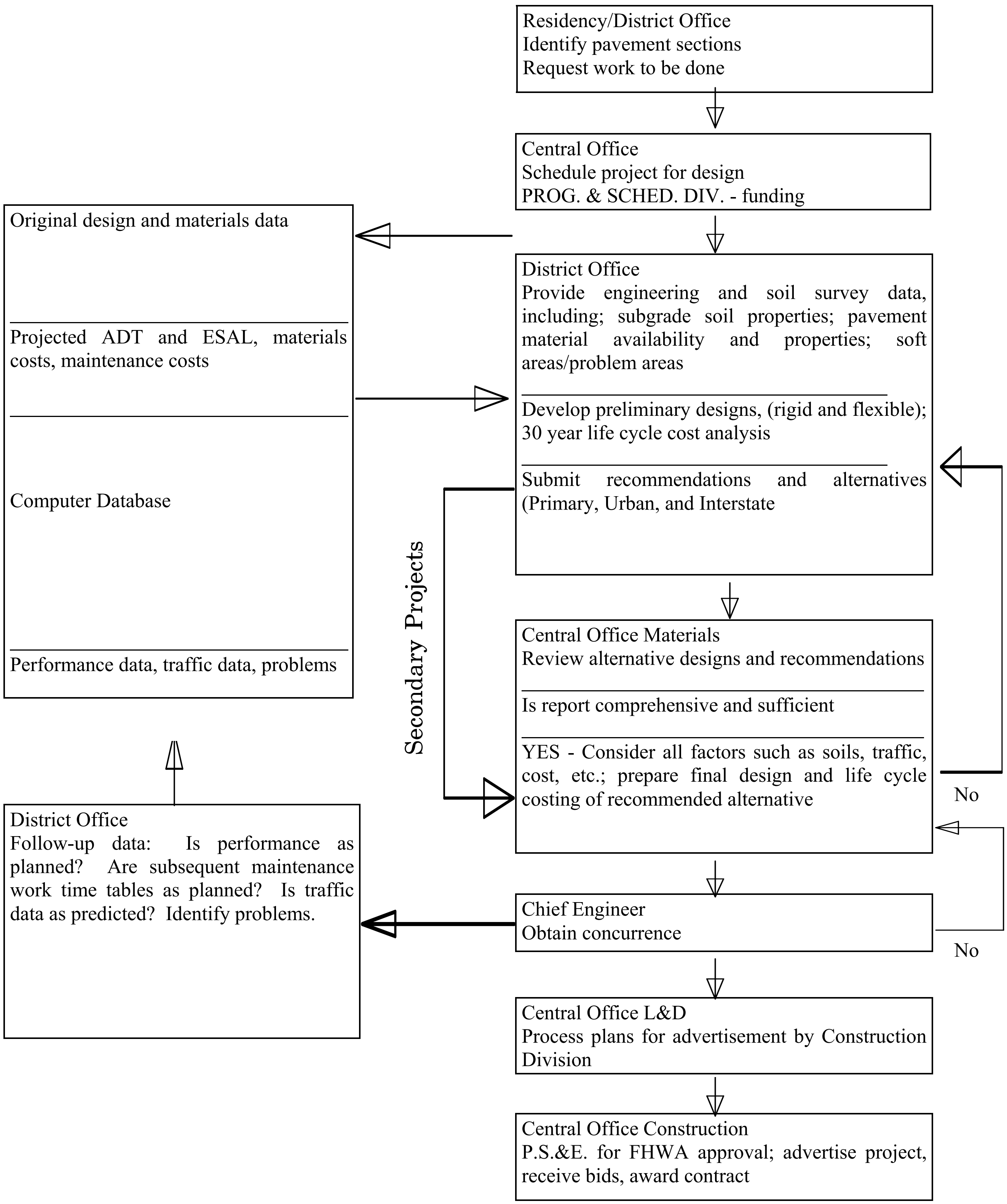


Structural Design Terms

1. Fill Slope
2. Original Ground
3. Curb or Curb and Gutter
4. Select Material or Prepared Roadbed
5. Shoulder Surfacing
6. Subbase
7. Base Course
8. Surface Course
9. Pavement Slab
10. Ditch Slope
11. Cut Slope
12. Shoulder Base
13. Pavement Cross Slope
14. Subgrade
15. Roadbed Soil
16. Pavement Structure
17. Shoulder Slope
18. Travel Lanes
19. Shoulder
20. Roadway
21. Roadbed

Figure 1. Typical Section for Rigid and Flexible Pavement Systems

Flowchart Depicting the Sequence of Events as Utilized in Virginia Pavement Design Approach



Guidelines for Asphalt Concrete Application Rates

Mix Type	Aggregate Size	Depth per Lift Min -Max	Normal Recommended Application Rate *
SM-1	3/8 inch (9.5 mm)	1 - 1.5 inch (25–40 mm)	1.25 inch-135#/sy (30mm-75kg/m^2)
SM-2A,B,C	1/2 inch (12.5 mm)	1.25 - 2 inch (30–50 mm)	1.5 inch . 165#/sy (40mm-100kg/m^2)
SM-3A,B,C	3/4 inch (19.0 mm)	2 - 2.5 inch (50–65 mm)***	2 inch. 220 #/sy (50mm-125kg/m^2)
IM-1A,B	3/4 inch (19.0 mm)	2 - 2.5 inch (50–65 mm)***	2 inch. 220 #/sy (50mm-125kg/m^2)
BM-1	3/4 inch (19.0 mm)	2 - 3 inch (40–75 mm)	**
BM-2	1 inch (25.0 mm)	2.5 - 4 inch (50–100 mm)	**
BM-3	1.5 inch (37.5 mm)	3 - 6 inch (75–150 mm)****	**

NOTE: This table is for design purposes. This table shall not supersede Section 315 of the Road and Bridge Specifications for field application rates.

* Application rate is based upon 110 pounds per square yard per inch (2.35 kg/m^2/mm) of thickness.

** Application rate for BM Type mixes should be determined from the actual specific gravity of the mixture as called for by the Materials Division or by region as indicated in the chart "Density of Base Asphalt Mixes for Approximate Quantity Calculations."

*** Depth per lift for shoulders can be a maximum of 3 inches (75 mm).

**** Low density may result when placing a 6 inch (150 mm) lift. The maximum thickness may be reduced if the mixture cannot be adequately placed in a single lift and compacted to required density and smoothness.

Density of Base Asphalt Mixes for Approximate Quantity Calculations

Note: To be used only if specific rates not provided in Pavement Design Report by the Materials Division.

Asphalt Concrete Weight in Pounds per Square Yard per Inch (kg/m^2/mm) of Depth for Base Mixes

DISTRICT	AREAS	BASE MIX BM-2, BM-3 Lbs./S.Y./In. (kg/m^2/mm)
Bristol	Abingdon-Marion-Wytheville-Galax	115 (2.46)
	Bluefield-Big Stone Gap-Woodway-Bristol	112 (2.39)
Salem	Buchanan-Roanoke-Salem-Radford-Martinsville	114 (2.43)
Lynchburg	Lynchburg	113 (2.41)
	Danville	110 (2.35)
	South Boston	111 (2.37)
Richmond		110 (2.35)
Suffolk		110 (2.35)
Fredricksburg		110 (2.35)
NoVa	Arlington-Fairfax	122 (2.61)
Culpeper	Charlottesville	118 (2.52)
	Culpeper-Flint Hill	113 (2.41)
Staunton		112 (2.39)

The weights of the asphalt mixtures listed above are based on 95% of theoretical maximum density.

Skid Testing Request Instructions

1. Requests for pavement friction testing originating in the field should be submitted by the District Administrator directly to the Friction Testing Unit Field Supervisor (presently located in the Lynchburg District). Copies of the request should be sent to the Maintenance Division and the Materials Division.

2. The request should include a brief history of the road with the following information:

   A. Current traffic count.

   B. Type of surface: asphalt concrete, slurry seal, etc.

   C. Type of aggregate used in the surface.

   D. Date the last treatment of the existing surface was applied.

   E. Comments should be included relative to the geometrics of the road, accident history, and the condition or appearance of the surface.

3. Upon completion of the friction testing, the Friction Test Unit Field Supervisor will furnish the District Administrator a report of the friction test results, with copies being sent to the Maintenance Division and the Materials Division.

4. The District Administrator (or a designated representative) is responsible for reviewing the friction test results and evaluating the pavement. After review and evaluation, the District Administrator will notify the State Maintenance Engineer of the proposed corrective action, furnishing a copy of the proposal to the State Materials Engineer.

5. Documentation of corrective action taken is very important. The District Administrator should notify the State Maintenance Engineer once the correction has been completed, listing what action was taken.

Request for Falling Weight Deflectometer Testing

The policy for requesting deflection testing, analysis, and reporting using the Falling Weight Deflectometer (FWD) is as listed below:

1. Low Distress Maintenance Rating (DMR) values, high roughness measurements, potential salvageability of pavement or other visual distress may be used as triggering systems to initiate your request for FWD Testing.

2. Submit your request for FWD testing as shown on the attached Form to the Pavement Nondestructive Testing Section, Lynchburg District, with a copy to the Pavement Design and Evaluation (PD&E) Engineer, at Elko.

3. FWD testing arrangements including date, time, and type of traffic control shall be done through the Pavement Nondestructive Testing Section, at Lynchburg.

4. Testing spacing and coring :

   a) Special request - Severe distress

      0 - 2 miles every 100 feet, 5 cores per mile
      (4 low and one high)

      (0 - 3 km every 30 m, 3 cores per km)

      (2 low and one high)

   b) General request - Project Level

      2.1 - 5 miles every 250 feet, 3 cores per mile

      (2 low and one high)

      (3.1 - 8 km every 75 m, 2 cores per km)

      (1 low and one high)

   c) Inventory, Net-Work Level

      > 5 miles every 500 feet, 2 cores per mile

      (one low and one high)

      (> 8 km every 150 m, 2 cores per km)

      (one low and one high)

When high deflections or severe pavement distress are encountered, the closer spacing, of 100 feet (30 m), shall be used. Selection of coring locations shall be based on the composite stiffness graph.

5. The testing crew shall provide the following todistrict personnel:

   a) Floppy disk with FWD data, with a copy to the PD&E Engineer, at Elko.

   b) Hard copy of the FWD data.

c) Three graphs representing composite stiffness, deflection basin, and subgrade resilient modulus.

d) One sheet to include the temperature profile of the pavement, and locations for pavement coring.

6. Coring, trenching, and verification of the pavement structure shall be done by the district personnel on the same day of testing.

7. Cores and copy of the temperature profile sheet shall be sent to the Asphalt Mixtures Laboratory at Elko, for resilient modulus testing. The results will be reviewed by the PD&E Engineer and reported to the District Materials Engineer.

8. District Personnel are encouraged to consult with PD&E Engineer, at Elko, before finalizing their recommendations.

9. The district materials personnel in charge of the analysis shall prepare the final report with their recommendations.

10. The final report shall be submitted by district personnel to the District Administrator, attention Maintenance/Construction Engineer, for appropriate actions, with a copy to the PD&E at Elko.

Virginia Department of Transportation

Request Form for Non-Destructive Testing

( ) Friction ( ) Roughness ( ) Deflection

Route:____________________

District:__________Residency:__________County:__________

Project Number (If applicable):____________________

Charge Number:____________________

Lane(s):__________Current Traffic Count:__________VPD

Type of Highway:__________Type of Surface__________

Length:__________Date Open to Traffic:__________

Description: From:__________M.P.__________

To:__________M.P.__________

Or Bridge:__________M.P.__________

	Layer	Thickness (mm/inches)	Description (AASHTO* Classification, Stabilization, Lime, Cement, Etc.)
FWD Only	Subgrade*		
	Stab. Subgrade		
	Subbase		
	Base/Slab		
	Binder		
	Surface		

Type of Aggregate in Surface (Granite, Limestone, etc.) __________

Reason for Request (Pavement Condition, DMR, etc.)

____

____

Remarks: (Overlay Thickness, Date, etc.)

____

____

Submit copy of request to:
Pavement Design Engineer (Elko)
Pavement Management Engineeer (Maint.)
NDT Section (Lynchburg Mat'ls.)

____
Signature Phone

____
Title Date

Life Cycle Cost Analysis

24 FOOT LANE MILE (7.2 METER LANE KILOMETER)
30 YEAR LIFE TO RECONSTRUCTION

DISCOUNT RATE: 4 % 13-Jun-95

PROJECT NUMBER: EXAMPLE

I PAVEMENT TYPE: CRCP
II SHOULDER TYPE: FLEX

YEAR	ACTION	COST
INITIAL COST INCLUDING SHOULDERS		300,000
1		
2		
3		
4		
5		
6		
7		
8	RESEAL BOTH SHOULDER JOINTS	3,300
9		
10		
11		
12		
13		
14		
15		
16	RESEAL ALL LONGITUDINAL JOINTS	5,000
17		
18		
19		
20	CPR 2% SURFACE AREA + GRIND 20% TRUCK LANE	24,000
21		
22		
23		
24	RESEAL BOTH SHOULDER JOINTS	3,300
25		
26		
27		
28		
29		
30		
PRESENT WORTH (INITIAL COST + MAINTENANCE)		318,014
ESTIMATED SALVAGE VALUE AT END OF 30 YEARS		150,000
TOTAL NET PRESENT WORTH		364,262
LIFE CYCLE COST ANALYSIS		

24 FOOT LANE MILE (7.2 METER LANE KILOMETER)
30 YEAR LIFE TO RECONSTRUCTION

DISCOUNT RATE: 4 % 13-Jun-95

PROJECT NUMBER: EXAMPLE

I PAVEMENT TYPE: CRCP
II SHOULDER TYPE: RIGID

YEAR	ACTION	COST
INITIAL COST INCLUDING SHOULDERS		300,000
1		
2		
3		
4		
5		
6		
7		
8		
9		
10	RESEAL LONGITUDINAL JOINTS	5,000
11		
12		
13		
14		
15		
16		
17		
18		
19	CPR - 2% SURFACE AREA + GRIND 20% TRK LN	26,500
20		125,000
21		
22		
23		
24		
25		
26		
27		
28	RESEAL LONGITUDINAL JOINTS	5,000
29		
30		
PRESENT WORTH (INITIAL COST + MAINTENANCE)		377,658
ESTIMATED SALVAGE VALUE AT END OF 30 YEARS		150,000
TOTAL NET PRESENT WORTH		423,906

LIFE CYCLE COST ANALYSIS
24 FOOT LANE MILE (7.2 METER LANE KILOMETER)
30 YEAR LIFE TO RECONSTRUCTION

DISCOUNT RATE: 4 % 13-Jun-95

PROJECT NUMBER: EXAMPLE

I PAVEMENT TYPE: FLEX
II SHOULDER TYPE: FLEX

YEAR	ACTION	COST
INITIAL COST INCLUDING SHOULDERS		300000
1		
2		
3		
4		
5		
6	PATCH (5% BOTH LANES, 1.5 inch(37.5 mm))	1250
7		
8	MILL & RESURFACE (BOTH LANES, 1.5 inch(37.5 mm))	20200
9		
10		
11		
12	PATCH (5% BOTH LANES, 1.5 inch(37.5 mm))	1250
13		
14		
15		
16	MILL&REPL. 15% BOTH LANES (3 inch(75 mm) BASE + 1.5 inch(37.5 mm) SURF)	24500
17		
18		
19		
20	PATCH (5% BOTH LANES, 1.5 inch(37.5 mm))	1250
21		
22		
23		
24	MILL & REPL. 3 inch (75 mm) TRK LN & OL BOTH LANES 1.5 inch(37.5 mm)	38700
25		
26		
27		
28	PATCH (5% BOTH LANES, 1.5 inch (37.5 mm))	1250 29
30		
PRESENT WORTH (INITIAL COST + MAINTENANCE)		347,522
ESTIMATED SALVAGE VALUE AT END OF 30 YEARS		150,000
TOTAL NET PRESENT WORTH		393,770

LIFE CYCLE COST ANALYSIS
24 FOOT LANE MILE (7.2 METER LANE KILOMETER)
30 YEAR LIFE TO RECONSTRUCTION

DISCOUNT RATE: 4 % 13-Jun-95

PROJECT NUMBER: EXAMPLE

I PAVEMENT TYPE: JPCP
II SHOULDER TYPE: FLEX

YEAR	ACTION	COST
INITIAL COST INCLUDING SHOULDERS		300,000
1		
2		
3		
4		
5		
6		
7		
8	RESEAL BOTH SHOULDER JOINTS	3,300
9		
10	RESEAL 10% TRANS. JNTS + CPR 2% TRANS. JNTS.	9,300
11		
12		
13		
14		
15		
16	RESEAL ALL LONG. JNTS.	5,000
17		
18		
19		
20	RES. 10% TR. JNT +CPR 2% TR. JNTS +GRND TK LN	23,000
21		
22		
23		
24	RESEAL BOTH SHOULDER JOINTS	3,300
25		
26		
27		
28		
29		
30		
PRESENT WORTH (INITIAL COST + MAINTENANCE)		324,074
ESTIMATED SALVAGE VALUE AT END OF 30 YEARS		150,000
TOTAL NET PRESENT WORTH		370,322

LIFE CYCLE COST ANALYSIS
24 FOOT LANE MILE (7.2 METER LANE KILOMETER)
30 YEAR LIFE TO RECONSTRUCTION

DISCOUNT RATE: 4 % 13-Jun-95

PROJECT NUMBER: EXAMPLE

I PAVEMENT TYPE: JPCP
II SHOULDER TYPE: RIGID

YEAR	ACTION	COST
	INITIAL COST INCLUDING SHOULDERS	300,000
1		
2		
3		
4		
5		
6		
7		
8		
9		
10	RESEAL 10% ALL JNTS + CPR 2% TRANS. JNTS.	10,600
11		
12		
13		
14		
15		
16		
17		
18		
19		
20	RES. 10% ALL JNT + CPR 2% TR. JNTS + GRND TK LN	24,400
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
PRESENT WORTH (INITIAL COST + MAINTENANCE)		319,029
ESTIMATED SALVAGE VALUE AT END OF 30 YEARS		150,000
TOTAL NET PRESENT WORTH		365,276